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ABSTRACT

One of twelve water treatment technology units, this student manual on taste, odor, and color provides instructional materials for three competencies. (The twelve units are designed for a continuing education training course for public water supply operators.) The competencies focus on the following areas: taste and odor determination, control of algae, and turbidity measurement. For each competency, student objectives, resources (information sheets and appendix material), learning activities, and evaluation activities are provided. The appendices contain information sheets on taste and odor control and laboratory equipment and supply requirements for a small water treatment plant providing complete treatment. (JH)

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Water Treatment Technology

TASTE, ODOR, & COLOR

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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CE 022 324

TASTE, ODOR, AND COLOR

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INSTRUCTIONS FOR THE STUDENT OPERATOR

The TASTE, ODOR & COLOR unit contains three competencies. A "competency" is a skill that is necessary for good on-the-job performance. Each competency in this unit is necessary for you to perform on the job according to the West Virginia Department of Health. There is a Competency Sheet to help you understand each competency.

DIRECTIONS FOR COMPLETING THE UNIT:

1. Read each Competency Sheet carefully. Every Competency Sheet contains:

   COMPETENCY
   Objectives
   RESOURCES
   LEARNING ACTIVITIES
   EVALUATION ACTIVITY(IES)

2. After reading the whole Competency Sheet, you should understand what will be expected of you.

3. Do the LEARNING ACTIVITIES that you think will help you the most. This may include reading some of the RESOURCES which have been included with the unit.

4. If you need additional help, ask an operator in your plant for assistance, or call your evaluator; he's there to help you.

5. When you are ready to complete the EVALUATION ACTIVITY for one or more competencies - - call your evaluator. The two of you will schedule the best time for your evaluation.

   a. If you complete the evaluation correctly, go on to the next competency.
   b. If you do <u>not</u> complete the evaluation correctly, your evaluator will tell you what your mistakes were. You must go back and practice your skills and read the RESOURCES again. *You must wait at least one week before being re-evaluated on a competency.*

SEE NEXT PAGE

6. When you complete all your evaluations correctly you will receive a Certificate of Accomplishment and 0.6 Continuing Education Units of Credit.

7. If you want to go on to another unit, contact your evaluator for the materials. The procedure will be similar for all units.

AN EXPLANATION OF CONTINUING EDUCATION UNITS

For student operators in the OPERATOR-IN-TRAINING category who will be taking the certification examination for Class I, this course is an opportunity to increase your knowledge and competence in the treatment of water for human consumption. Successful completion of the manuals will also, it is hoped, make passing the certification exam much easier. The Continuing Education Units which you will get by taking this course will not decrease the minimum one year operating experience requirement for a Class I certificate.

For student operators who now hold a Class I certificate, the completion of all twelve manuals in the course will reduce the currently required three years of total operating experience for Class II certification by approximately four months. Thus, if you complete the course, you will need only two years and eight months of total operating experience before you take the Class II exam.

Here is a listing of the Continuing Education Unit (CEU) value of each of the manuals.

Manual	CEU Value
General Plant Operation	1.4
Taste, Odor, and Color	0.6
Chemistry/Bacteriology	2.5
Chlorination	2.5
Fluoridation	0.6
Filtration	1.2
Hydraulics	0.6
Distribution Systems	1.2
Pumps	0.6
Wells	1.0
Cross Connections	0.4
Springs	0.4
Total	13.0

For comparison with other types of training previously available, the CEU conversions below are given.

Public Water Supply Operator's Short Course (given by State Department of Health Personnel)	4 CEUs
One Semester Hour of College Credit	1.5 CEUs
One Year of College Credits (30 semester hours)	45 CEUs

COMPETENCY: Demonstrate the ability to test your finished water for taste and odor and perform necessary corrections.

Objective: Demonstrate the ability to test your finished water for taste and make necessary corrections.

Objective: Identify probable sources of unpleasant tastes in your finished water.

Objective: Demonstrate the ability to test your finished water for odor and make necessary corrections.

Objective: Identify probable sources of unpleasant odors in your finished water.

RESOURCES:

(a) "Taste and Odor Determination", Resource Sheet.

(b) Manual of Instruction for Water Treatment Plant Operators, New York State Department of Health, Health Education Service, P. O. Box 7283, Albany, New York 12224, Chapter 14. *-Yellow Appendix-*

(c) Laboratory Equipment and Supply Requirements for a Small Water Treatment Plant Providing Complete Treatment *-Gold Appendix-*

LEARNING ACTIVITIES:

(a) Using the Resources listed above as a guide, test your finished water for taste (get additional opinions on the taste test if possible). If there is no objectionable taste go to "c" below. If any objectionable taste is present, describe the taste to the best of your ability. Use the Resources and your familiarity with your treatment plant water sources to determine a probable *cause* for the taste.

(b) Perform the necessary corrections to eliminate the objectionable taste from the water. Re-test the water for taste to make sure that you have corrected the problem.

Be sure to keep accurate records of the steps you take to correct taste problems. Include the date, and describe the objectionable taste, the suspected source of the problem, and any corrective steps you take. Do not hesitate to check with an experienced operator or the W. Va. Department of Health if you have trouble clearing up a taste problem.

(c) Using the Resources listed above as a guide, test your finished water for odor. If possible, have one or two additional persons help you test for odor. One opinion is not always reliable in odor tests. If any objectionable odor is present describe the odor to the best of your ability. Use the Resources and your familiarity with your treatment plant water sources to determine a probable *cause* for the odor.

(d) Perform the necessary corrections to eliminate the objectionable odor from the water. Re-test the water for odor to make sure you have corrected the problem.

Be sure to keep accurate records of any steps you take to correct an odor problem. Check with an experienced operator and/or the W. Va. Department of Health if you have any trouble clearing up a water odor problem.

EVALUATION ACTIVITIES: While you evaluator observes:

(a) Perform a test for taste on your finished water. If there is an objectionable taste (1) identify the probable source(s) of the problem and (2) perform the necessary corrections.

(b) Perform a test for odor on your finished water. If there is an objectionable odor (1) identify the probable source(s) of the problem and (2) perform the necessary corrections.

TASTE AND ODOR DETERMINATION*

1. Purpose of Test

Objectionable tastes and odors in water can be caused by plankton, actinomycetes, bacteria, decaying vegetation, inadequately treated domestic wastes, and industrial wastes. Corrective measures designed to reduce or eliminate unpleasant tastes and odors include aeration as well as the application of free residual chlorine, chlorine-ammonia, chlorine dioxide, activated carbon, and copper sulfate. An important objective of a water treatment plant is to produce a finished water which is free of unpleasant tastes and odors.

This simple qualitative method is designed for routine determinations in small water plant laboratories. The test is suitable for potable water samples and water supplies undergoing treatment.

2. Warning

The taste test should be applied only to waters known to be safe for drinking. Where possible, the majority opinion of several testers should be sought and recorded.

When a more quantitative appraisal of the character and intensity of the taste and odor is desired, the procedures in the latest edition of *Standard Methods* should be followed.

3. Apparatus

3.1. Two or more 500 ml wide-mouth glass-stoppered bottles or flasks. Remove all trace of taste and odor from the interior and exterior of the bottles or flasks by scrubbing with nonodorous cleansers or hydrochloric acid. Finally, rinse with several portions of odor-free water. Set these bottles or flasks aside for exclusive use in the taste and odor determination. Store, if possible, by immersing the bottles or flasks in odor-free water.

3.2. Thermometer, 0-110°C, of the mercury or metal-stem dial type.

3.3. Odor-free water generator. See Fig. 1.

4. Odor-Free Water

Prepare the odor-free water generator as shown in Fig. 1. Before charging the generator with activated carbon, thoroughly clean the gravel, tubing, and the 1 gallon jug with a nonodorous cleanser or hydrochloric acid and rinse several times with distilled water. After the generator is connected to the tap water line, allow the tap water

*Source: Simplified Procedures for Water Examination-Laboratory Manual, American Water Works Association, AWWA No. M12, 1975, pp. 94-97.

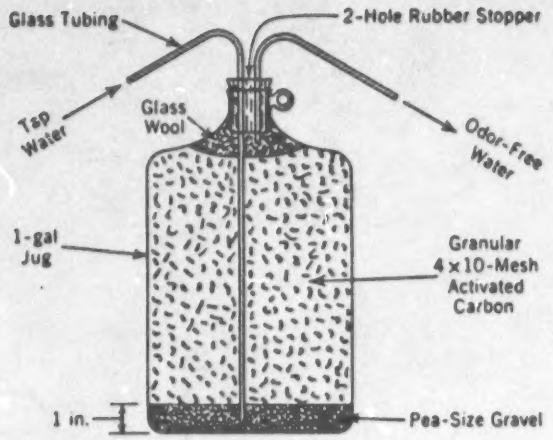

Fig. 1. Odor-Free Water Generator

to pass through for a short time to wash out the fine carbon particles, before starting the collection of the odor-free water. Operate the generator at a rate of 1 liter per minute. Use the DPD method to check the residual chlorine in the collected water if the tap water has been chlorinated. Replace the activated carbon when residual chlorine appears in the collected water.

5. Procedure

5.1. Taste and odor quality at collection temperature:

(a) Fill one bottle or flask half full of odor-free water and replace the glass stopper. Use this water as the comparison blank.

(b) Fill the second bottle or flask half full of sample and replace the glass stopper.

(c) Vigorously shake the contents of the bottle containing the odor-free water, remove the stopper, and immediately sniff the odor.

(d) Without delay, vigorously shake the contents of the bottle containing the sample, remove the stopper, and also sniff the odor. Record the odor by the code shown in Table A.

(e) Pour 10 ml of the sample into a beaker and place the water in the mouth. Hold the water in the mouth for several seconds and then spit it out. Note the taste while the sample is in the mouth, as well as the aftertaste.

Do not taste any sample which may be unsafe for drinking.

TABLE A

Qualitative Descriptions of Odors

Code	Nature of Odor	Description (Such as Odors of:)
A	Aromatic (spicy)	camphor, cloves, lavender, lemon
Ac	cucumber	*Synura*
B	Balsamic (flowery)	geranium, violet, vanilla
Bg	geranium	*Asterionella*
Bn	nasturtium	*Aphanizomenon*
Bs	sweetish	*Coelosphaerium*
Bv	violet	*Mallomonas*
C	Chemical	industrial wastes or treatment chemicals
Cc	chlorinous	free chlorine
Ch	hydrocarbon	oil refinery wastes
Cm	medicinal	phenol and iodoform
Cs	sulfuretted	hydrogen sulfide or rotten eggs
D	Disagreeable	(pronouncedly unpleasant)
Df	fishy	*Uroglenopsis, Dinobryon*
Dp	pigpen	*Anabaena*
Ds	septic	stale sewage
E	Earthy	damp earth
Ep	peaty	peat
G	Grassy	crushed grass
M	Musty	decomposing straw
Mm	moldy	damp cellar
V	Vegetable	root vegetables

5.2. Taste and odor quality at elevated temperatures:

(a) Warm the bottles or flasks containing the odor-free water and the sample - Steps 5.1(a) and 5.1(b) - to 40°C.

(b) Carry out Steps 5.1(c) through 5.1(e). Record the taste due to chlorination as "chlorinous" and that due to chlorophenol as "medicinal".

(c) Repeat the above procedure at 60°C.

COMPETENCY: Describe the best procedure for the control of algae at your treatment plant.

Objective: Describe the conditions necessary for algae to grow.

Objective: Describe what problems can be caused by excessive algae.

Objective: Describe various ways in which algae can be controlled.

Objective: Describe the most efficient means for controlling algae at your treatment plant.

RESOURCES:

(a) "Algae Control", Resource Sheet.

(b) Manual of Instruction for Water Treatment Plant Operators, New York State Department of Health, Health Education Service, P. O. Box 7283, Albany, New York 12224, Chapter 14. *-Yellow Appendix-*

(c) Maintenance and Operation of Water Plants and Systems, Department of the Air Force, Air Force Manual No. 85-13, June 15, 1968, pp. 156-160. *-Blue Appendix-*

LEARNING ACTIVITIES:

(a) Read the Resources listed above to find information about algae control.

(b) Examine a sample of algae from your reservoir or storage basin under a microscope. Using the *Yellow Appendix* try to identify the type of algae present.

(c) Describe the color, odor, and taste of the algae at your treatment plant.

(d) 1. Find out how algae at your treatment plant were controlled in the past.

--Were chemicals used? What kind and how much?
--How were the chemicals administered?
--Were fish killed as a result of the algae control?

2. What type of algae control do you recommend for your treatment plant. Why?

EVALUATION ACTIVITY: Complete Evaluation Form # 9. You will be expected to answer some general questions about algae control. You will also be expected to describe the best procedure(s) for controlling algae at your treatment plant. You may not use references.

"ALGAE CONTROL"*

a. *General.* Presence of algae does not make water unsafe. However, uncontrolled algae growth frequently causes unpleasant tastes and odors and it may clog pipes and filter beds, thus lowering efficiency. Filter difficulties are generally caused by a small group of diatoms. Taste and odor problems are generally caused by a wide variety of algae, the type and intensity of the problem varying with the particular algae concerned. Algae growth occurs mainly in large open reservoirs in sluggish streams, and in surface supplies. Sunlight is necessary for its existence.

b. *Types of Treatment.* Algae growth can be controlled by the use of algicidal chemicals and the alteration of environmental conditions such as the reduction of light intensity, the latter being applicable usually only in small storage basins and tanks. Control of algae with copper sulfate, chlorine, or activated carbon are standard methods of control using chemicals.

(1) *Copper Sulfate.* In soft water, 1 ppm of copper sulfate (8.3 pounds per million gallons of water) destroys most algae. Larger dosages are needed in hard water because the alkaline agents in hard water precipitate some of the copper. Effective hard-water dosage may be from 1 to 4.5 ppm, depending on alkalinity of the water. Because copper sulfate kills fish, its use is limited. Concentrations that kill common varieties of fish are listed below in pounds of copper sulfate per million gallons of soft water. Fatal concentrations are considerably higher in hard waters.

	$lbs/10^6$ gal.	mg/l
Trout	1.2	0.14
Catfish	2.5	0.3
Suckers	2.5	0.3
Carp	2.5	0.3
Pickerel	3.5	0.4
Black bass	17.0	2.0
Goldfish	4.0	0.5
Perch	6.0	0.72

(2) *Chlorine.* Chlorine dosage at the plant of 0.3 to 1 ppm destroys most algae but may intensify tastes and odors. The breakpoint method of chlorination requires higher dosages but eliminates taste and odor as well as algae. With this method of chlorination, dosages vary from 0.8 to 10 ppm, or higher in exceptional cases. Chloromines have in some instances also been found to be an effective method of controlling algae growths.

(3) *Copper Sulfate and Chlorine.* Use of both copper sulfate and chlorine in the reservoir is especially effective when the growth to be eliminated requires a copper sulfate concentration that would kill the fish present. Maximum allowable copper sulfate is added, and the amount of chlorine needed to supplement it is determined by trial.

*Source: Maintenance and Operation of Water Plants and Systems, Dept. of the Air Force, Air Force Manual No. 85-13, Reprint dated June 15, 1968, pp. 160-161.

(4) *Activated Carbon.* Because algae grow only in sunlight, they can be eliminated by preventing light from entering the water. This is the principle behind the activated-carbon method of algae control. Usually, 6 to 20 pounds of carbon per million gallons places enough carbon in suspension to absorb all light. The carbon also removes tastes and odors in the water.

(5) *Flocculation and Sedimentation.* In some cases it is necessary to increase the coagulant dosage or use copper sulfate and prechlorination with the coagulant to produce a more settleable floc, thus improving coagulation and aiding the removal of algae in the setting basin.

c. *Mehods of Application.* Before any chemical is applied, the volume of water in the reservoir to be treated is computed carefully to avoid underdosing or overdosing. Underdosing is ineffective and overdosing wasteful. Too much copper sulfate destroys fish life and affects the quality of the water. Usually only that part of a reservoir showing algae growths should be treated. There is little need for applying algicides to water containing no algae. In this connection, algae growths are usually found in shallow areas and around the shore line. In computing water volume, the depth is taken as 5 feet; algae do not generally grow below a 5-foot depth because that is the maximum effective penetration of sunlight. Having computed water volume and calculated dosage, the treatment chemical can be applied by one of the methods below.

(1) *Copper Sulfate.* Copper sulfate treatment is most effective if started early in the season before heavy algae concentration has formed. The treatment is repeated whenever algae growths reappear. If copper sulfate can be applied by solution feeder to water entering the reservoir, continuous application of lower concentrations can be used instead of intermittent treatment. This usually results in the most efficient control of algae growths. Copper sulfate treatment should be started when the algae count exceeds 20 organisms per millimeter of water, as measured by the centrifugal or Sedgewick-Rafter funnel methods or by microscopic examinations.

(a) The simplest, though not the best method, of applying copper sulfate is to tie a bag of copper sulfate crystals to a boat and cover the reservoir in a definite zigzag pattern.

(b) In reservoirs needing frequent treatment, the best method is to spray copper sulfate solution on the water surface from a spray unit mounted in a boat. Apply the solution evenly to avoid overdosing shallow areas.

(2) *Chlorine.* Chlorine may be applied as hypochlorite solution or chlorine gas. Hypochlorite is sprayed on the water from a boat-mounted spray unit. Gas is fed from a boat-mounted chlorinator through a submerged diffuser into the water. Either may be fed continuously when controlled dosage can be applied to water entering the reservoir.

(3) *Activated Carbon.* In large reservoirs and impounded supplies, activated carbon is applied by spray from a boat. In small basins, regular spraying and hand spreading can be used. In filtration plants carbon is usually added before coagulation. Suspended carbon carried to the filters is effective in removing odors, although shortening of filter runs may occur.

Color Removal

a. *General.* Color in natural waters is caused mainly by vegetable dyes or by excessive amounts of iron and manganese. Minerals contained in industrial wastes may also cause color. The coloration is usually caused by colloidal matter and may be removed in the same manner as other colloids, by chemical precipitation, coagulation or adsorption, followed by filtration.

b. *Treatment Methods.* No one method will remove all colors and no rule will apply to all waters. Color removal requires trial of the following methods to determine which is most efficient and economical in the particular case.

(1) Coagulation with alum, followed by lime or soda ash if necessary, and filtration is the most common method. The alum must be added first and given some reaction time at a pH of 5.5 to 6.0 before adding the alkali. If the alkali is added first, it will "set" the colors and prevent removal.

(2) Color removal by chlorination requires a dosage of 1.0 to 10.0 ppm, the correct amount being determined by trial. A detention or contact time of at least 15 minutes is necessary and not less than 0.1 mg/l free or combines residual should be maintained.

(3) The addition of chlorinated copperas at a low pH with an alum dose applied halfway through the coagulation basin has been very successful in some instances. Dosage has to be determined by trial.

(4) Some color is susceptible to removal with activated carbon. The colloidal matter is adsorbed by carbon atoms with free valences and is removed by sedimentation and filtration. Tests of carbon applied to the particular water are the only method of determining the effect of carbon for color removal.

COMPETENCY: Perform tests to determine the level of turbidity of your finished water.

Objective: Define turbidity and describe its causes.

Objective: Perform tests to determine the turbidity level of your finished water.

RESOURCES:

(a) "Turbidity", Resource Sheet I.

(b) Laboratory Equipment and Supply Requirements For a Small Water Treatment Plant Providing Complete Treatment *-Gold Appendix-*

LEARNING ACTIVITIES:

(a) Read the Resources listed above to find information about turbidity.

(b) Using "Turbidity", Resource Sheet I (or other reference of your choice), practice performing turbidity tests on your finished water. If possible, ask an experienced operator to observe your testing to make sure you are following all procedures correctly.

EVALUATION ACTIVITY: You will be expected to perform a test to determine the turbidity of your finished water. You must report your results accurately. You may use references.

TURBIDITY

WHAT IS TURBIDITY?

A. The "Dictionary" Definition

The Oxford Concise Dictionary defines "turbid" as meaning (of a liquid) muddy, thick or not clear. "Turbid" comes from a Latin word "turbidus" meaning "disturbed".

B. The "Standard Methods" Definition

"Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms."

Turbidity should be clearly understood to be an expression of the optical property of a sample which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample.

C. General Remarks - Turbidity vs. Sediment

Suspended impurities or materials may range in size from colloidal particles to coarse, relatively heavy materials which can be kept in suspension only by stirring or a turbulent flow. The line of distinction between turbidity and sediment is not well defined. However, especially in the area of waste water analysis, it is important to be consistent and measure after the same time interval or with the sample being stirred. Naturally, the procedures accepted within an area of discipline are the ones to follow. Dissolved solids are not measured by turbidimeters. Colour due to a colloidal suspension is measured as turbidity. Air in the form of bubbles is also read as turbidity.

WHY IS TURBIDITY MEASURED?

To the water filtration plant operator, turbidity is an indicator of the effectiveness of a) the flocculants used (i.e. alum, polyelectrolytes) to cause suspended materials to floc or group together for quicker and more effective filtering, and b) the filtration system (i.e. sand-beds or special filtering devices.

To the waste-water treatment plant operator, turbidity is a useful indicator of a) loading conditions (i.e. storm sewer effects with severe rain storms), b) effectiveness of chemical treatment, and c) overall plant operation in terms of suspended materials in the final effluent (i.e. impact of waste detention time in system on floc).

As a general rule high turbidity reduces the effectiveness of chemical and bacteriological treatment systems. Systems are available for continuous monitoring or grab sample measurement of turbidity.

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HOW IS TURBIDITY MEASURED?

Introduction: Solids Measurement vs. Turbidity

Reference has been made above to suspended solids, colloids, dissolved solids and sediment. In the water analysis field, there are several phases or aspects to "Solids Measurement".

Solids can exist in wastewater or water in several forms. The table indicates approved methods of measurement.

1. Sediment or settled solids.
2. Suspended solids.
3. Dissolved solids - in solution.
4. Volatile solids.

Type of Solid	Method	Reference Page Number for "Std. Methods" (13th Ed.)	EPA
Sediment or Settled	By Wt. or Vol. Imhoff Cone	539	273
Suspended	Glass-fibre filtration (103°-105° C.)	537	268
Dissolved	Glass-fibre filtration (180° C.)	537	266
Volatile	Gravimetric (550°)	536	272

The above are all related and measured essentially by filtration, evaporation and gravimetry in one form or combination thereof. Turbidity, though directly related to suspended solids and colloidal matter, is not considered at this time to be a quantitative measurement. A qualitative measurement it certainly is. "Good water usually looks good".

A SHORT HISTORY

In 1900 [illegible] researchers, Jackson and Whipple, reporting in an MIT Quarterly of that year, described a unit subsequently known as the Jackson Candle Turbidimeter, for the measurement of turbid solutions by relating levels of sample waters in a graduated cylinder to visible loss or merging of the image of a candle viewed from the top of the column of water, with the lighted candle fixed at a defined distance from the bottom side of the graduated column. (See sketch) The Jackson Turbidity Unit of measurement resulted - hence the now well-known JTU's.

As more studies followed, various standard solutions were offered. Originally the "Jackson Unit" was related to ppm concentrations of standard silica suspensions.

In 1926 Kingsbury and co-workers described the standard material called Formazin. This polymeric material is simple to prepare though not ideally stable. From this derived the Formazin Turbidity Unit and short form FTU's.

As the age of electronics has a habit of doing, it soon caught up with turbidimetry. Photon (light energy) detectors substituted for the eye and tungsten filaments replaced the Jackson "candle".

More research further indicated that the separate measurement or comparison of the light transmitted through a sample suffered from a) insensitivity in the low ranges (0-5 JTU) and b) non-linearity in the high ranges.

By 1966, R. B. Fischer, writing a text on Turbidity, found it necessary to distinguish between "TURBIDITY" and "NEPHELOMETRY" as follows:

> "In Turbidity measurement is made of the intensity of light transmitted through the medium, i.e. of the unscattered light."
>
> "In Nephelometry the intensity of the scattered light is measured, usually, but not necessarily, at right angles to the incident light beam."

Nephelometers are now the most widely used systems for measuring turbidity. Improved optics and electronics have now made it possible to measure turbidity quickly using a single reference standard and in any range, without re-calibration or dilution procedures. The problems of insensitivity and non-linearity have been resolved for most areas of water and waste-water analysis.

INSTRUMENTATION: Description & Operation

In the EPA manual "Methods for Chemical Analysis of Water and Wastes," EPA-625/6-74-003 (1974), the requirements for turbidimeters are delineated. In part, the basic requirement is:

> "The turbidimeter shall consist of a nephelometer with light source for illuminating the sample and one or more photoelectric detectors with a readout device to indicate intensity of light scattered at right angles to the path of the incident light."

The optical system shown in Fig. 2 is a true nephelometric turbidity detection device which also measures the transmitted light. This combination, together with special electronics, makes it now possible to measure high turbidity values without needing to dilute the sample or recalibrate when changing ranges. To operate

this generation of turbidimeter, you need only one known reference standard as provided, which is near zero FTU or JTU, and clean sample cuvets. The measuring procedure is simple:

1. Place 0.12 FTU Reference Standard in cell.

2. Turn "Range" to "1', (0-1.0 JTU).

3. Using "Reference Adjust", make meter read 0.12 FTU or JTU/NTU.

4. Replace "Standard" with sample and read value directly on the meter.

Note: It may be necessary to switch ranges until meter needle is on scale, but recalibration and dilution is not required.

Fig. 1

JACKSON CANDLE
TURBIDIMETER

GLOSSARY OF TERMS

COLLOIDAL SUSPENSION	A suspension of uniform particle sizes in the millimicron range and smaller.
FLOCCULANT	A chemical used which causes fine suspensions to agglomerate into larger masses for faster settling and more efficient filtration.
FTU	A standard unit of turbidity
JTU	A unit of turbidity - Jackson Turbidity Unit.
% LIGHT TRANSMITTANCE	This is a measurement of opacity of a liquid. 100% light transmittance indicates that the liquid is free from any suspension.
NEPHELOMETER	An Instrument which measures scattered light at 90° to the incident light beam.
NTU	A unit of turbidity measured by a nephelometer - Nephelometric Turbidity Unit.
SUSPENDED SOLIDS	Generally particles vary from 50 microns to much larger sizes.
TURBIDITY	A uniform suspension of finely divided particles which do not settle rapidly. Sizes of particulate matter can vary from about 50 microns in size to millicrons and lower. It can consist of any type of inorganic and organic material.

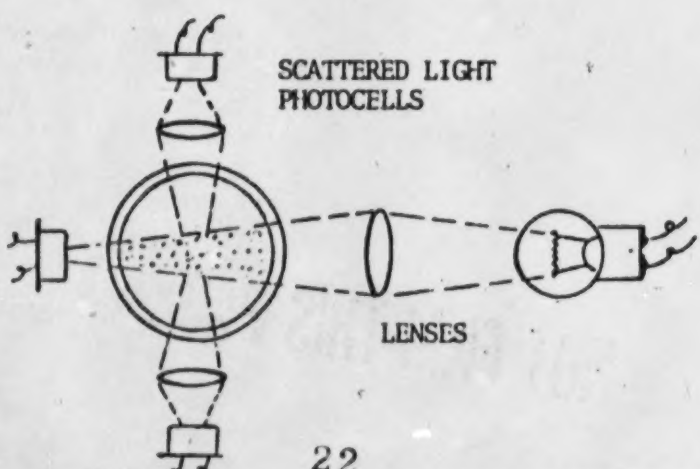


Fig. 2

H.F. INSTRUMENTS
DIRECT READING
TURBIDIMETER OPTICS

TASTE AND ODOR CONTROL*

The average consumer judges water quality by color, sparkle and taste. He assumes the water will not cause intestinal disease. This is an impressive tribute to the water treatment plant operator. Those concerned with development of public water supplies predict that taste and odor problems will become more intense in the near future. Pollution of surface water by human and industrial wastes and the ever-increasing re-use of water are problems which water plant operators will have to face for some time to come. Probably in the future, as now, the greatest number of consumer complaints about treated surface waters will concern unsatisfactory odor and taste.

Sources of Taste and Odor

Industrial wastes, human wastes, nuisance plant growths and naturally occurring substances may from time to time or continuously contribute to the taste and odor problem. Although industrial wastes are not the prime source of taste and odor, they will be considered first.

Industrial Wastes

As a result of an *industrial spill* or a cleanup operation, an intermittent and intense taste and odor problem may be created. Persistent problems may be caused by continuous discharge of process wastes. Phenols and related compounds are often the source of medicinal tastes--tastes which are intensified by chlorination. Hydrocarbonsfrom refinery wastes often can be recognized by an oily film on the water surface. As little as 0.025 to 0.050 mg per liter of such wastes has caused taste and odor outbreaks. Some chemical wastes, such as ethyl acrylate and N-butyl mercaptan, have been detected by the threshold odor test at 0.006 and 0.007 mg per liter respectively. Odors resulting from pulp and paper wastes have been described as "sulfite" or "paper-mill." Even though these terms are neither very descriptive nor precise, anyone who has been inside a paper mill will instantly recognize the typical odor of such wastes. Wastes from the metal processing industry may cause tastes, but not odors. Zinc, copper, and other metals produce characteristic tastes.

Sewage

Sewage contains a mixture of organic materials. In sewage treatment, some of these compounds may be partially oxidized and produce odor. When sewage is chlorinated to control bacteria, the effluent may have a chlorinous odor, due to the formation of chlororganic compounds.

*Source: Manual of Instruction for Water Treatment Plant Operators, New York State Department of Health, Health Education Services, P.O. Box 7283, Albany, N. Y. 12224, pp. 187-196.

Sewage polluted water contains a relatively high concentration of nitrogen compounds. These may releaseammonia which reacts with free chlorine to produce nitrogen trichloride. This compound has a very persistent and irritating odor. A procedure for detecting nitrogen trichloride is given later in this Appendix.

Algae

Of all causes of taste and odor problems, algae are most important. Algae are simple forms of plant life widely distributed in nature and usually present in lakes, ponds, and reservoirs. Most of them are microscopic in size and vary from single cells to filaments, chains, or groups of cells. Since there are thousands of varieties of algae, it is nearly impossible to become familiar with more than a few. Some of the more important taste and odor-producers are pictured in Figures 1 and 2 (on the following pages).

Algae may be grouped as follows to aid their identification:

Cyanophyceae--These, more than any others, are responsible for taste and odor in water supplies. They are blue-green and float on the water surface. *Anabaena* and *Aphanizomenon* produce very offensive tastes and odors.

Diatomaceae--These are one-celled plants which reproduce by splitting. The cell walls contain green and brown coloring matter. Dead organisms produce a fishy or geranium odor in the spring and fall. *Asterionella* is an example of this group.

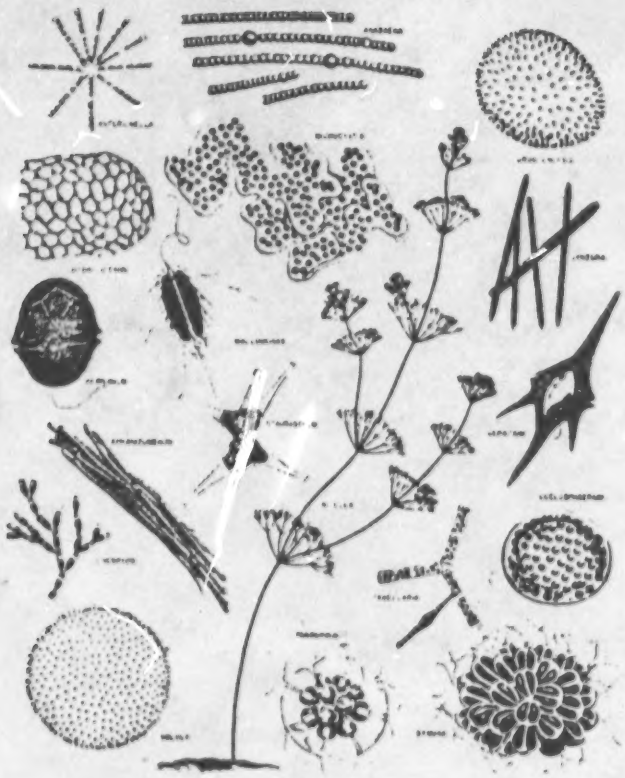
Chlorophyceae--These are the green algae; they are also mostly free floaters and produce a grassy or fishy odor and taste.

Since algae are aquatic plants (without roots), they require the same conditions for optimum growth as land plants, namely sunlight and nutrients. Analyses of algae have shown as much as 10 per cent nitrogen and significant amounts of phosphorous in their cells. Nitrogen and phosphorous are the important components of fertilizers.

This may be one reason why certain bodies of water support heavy algae growths and others do not. There may be other reasons. Pool size, shape, depth, amount of shore line, extent of shoal areas, character of the bottom, physiography and soils of the watershed, amount and rate of precipitation, sunlight, and the quality of the water are all factors influencing the growth of algae in a reservoir.

Other Microorganisms

Protozoa--These organisms belong to the lowest and simplest forms of animal life. Some forms have characteristics of both animals and plants. Examples of this group are *Dinobryon* and *Synura*. Odors and tastes associated with this group have been described as fishy, aromatic, cucumber-like, or muskmelon-like.



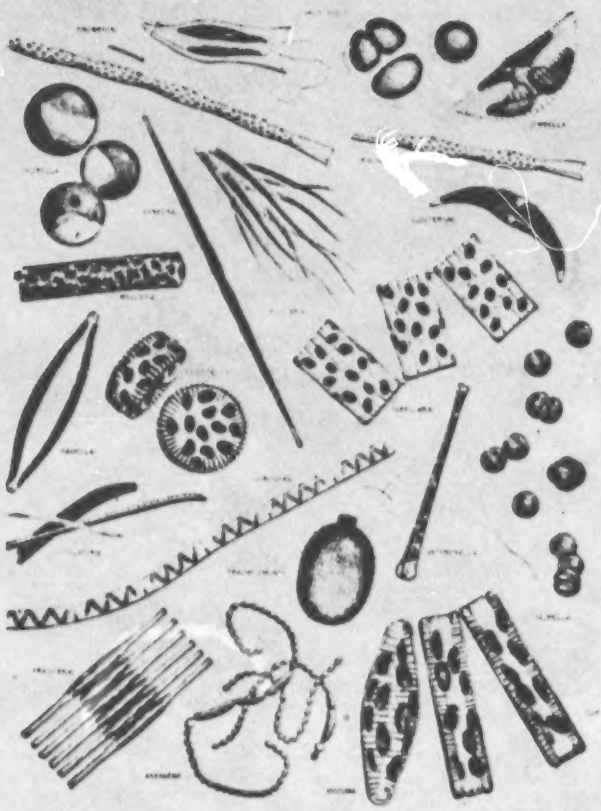
TASTE AND ODOR CAUSING ALGAE

Schizomycetes--These cause hydrogen sulfide in water supplies and are known as iron and sulfur bacteria. *Crenothrix* and *Beggiatoa* are examples. They are most often found in ground waters, and produce a very offensive decayed odor.

Actinomycetes--Closely allied to the microscopic plants is another group of organisms known as *Actinomycetes*. They are unicellular, filamentous organisms which occupy a separate group between the fungi and bacteria, but are more closely associated with bacteria than fungi. They account for a large part of the microbial population of soils and lake and river muds. Odors associated with these organisms have been described as earthy or musty and may have been incorrectly attributed to algae when the actual source was *Actinomycetes*.

Miscellaneous Sources of Taste and Odor

The following are not primary sources of taste and odor, but cause occasional problems. For pest control, various chemicals have been employed, such as insecticides, fish poisons, and herbicides. Care-



FILTER CLOGGING ALGAE

less application has permitted some of these pesticides to enter streams which serve as sources of public water supplies. Usually the taste and odor problems have been associated with the solvents used to disperse the chemicals.

Decaying plants and leaves have been suspected in certain outbreaks of taste and odor. From 0.005 to 0.020 mg per liter of phenol has been reported in virgin streams. Tannins leached from oak leaves probably form phenols by decay.

Detection Procedures

Before treatment can be started, the problem must be identified. Control procedures must be established which will determine the intensity and character, as well as changes in taste and odor in the influent and effluent. How often this determination should be made will depend upon the variations in the raw water.

Other tests may be used in addition to, or in place of, the threshold odor determination. One of the most elaborate of these has been developed by Gerstein. By this device, results similar to the threshold odor determination can be obtained. In the simplest form of this monitor, water is passed continuously through an electric heater where it is warmed to 120-140°F. The heated water is carried to a spray nozzle inside an enclosed glass cylinder where the water is sprayed in a mist. The odor released is sniffed by an operator through an opening in the top of the glass cylinder. By mixing heated odor-free water in proper proportion with the sample, a threshold odor value may be obtained. Total cost of a 2,000-watt Chromalox heater, with rotameter flow valves and fittings, is minimal. A hot water fountain connected to the chlorinated final effluent line can provide water at 120-140°F for the operator to sniff or taste at regular intervals. The elevated temperature of a hot water fountain helps the operator detect taste and odor changes.

A similar test can be performed using only a few Erlenmeyer flasks and a thermometer. The sample to be tested is heated to 140°F. Chlorinated samples may be tasted as well as sniffed. Each operator on each shift can make this determination as many times as is required.

Odor may be detected wherever there are large volumes of water in agitation, for example, at weirs, aeration units, or recarbonation basins. Many operators have been very successful detecting changes in odors by frequent inspections at these points.

Preventive Treatment

Whenever possible, it is better to prevent tastes and odors from developing in raw water than to depend on corrective measures for their elimination. However, when supplies are taken from large lakes or reservoirs, preventive measures may not be practical.

Copper Sulfate

Since the algae and other microorganisms are among the most frequent causes of tastes and odors, prevention of their growth is desirable. Probably the most effective and common treatment in reservoirs is the application of copper sulfate. It is a very effective poison for microscopic vegetation and animal life and may be used in doses of 12 mg/l or more without danger of copper poisoning to water consumers. The copper sulfate dose must be limited, however, to prevent fish kills. Objectionable tastes may be produced when concentrations of copper sulfate are beyond 4 mg/l. Most microorganisms will be killed at concentrations considerably below this figure and also below that which is destructive to fish life. Most fish can tolerate doses up to about 0.5 mg/l and practically none will be affected at 0.3 mg/l.

The dose of copper sulfate should be based on the results of microscopic examinations of water samples. Various organisms require different concentrations for their destruction. In the absence of such examination, moderate doses of about 0.3 mg/l or 2.5 pounds per million gallons will kill most of the taste and odor-producing organisms.

The number of pounds of copper sulfate required should be computed on the basis of only a 10 foot depth of water and should be applied at intervals of two to four weeks during the warmer period of the year, except when information is available to serve as a guide for more specific treatment.

Effective control throughout the year is facilitated by the continuous application of about 1.5 pounds per million gallons, about 0.18 mg/l, to the water entering the reservoir. In that way microorganisms are controlled before heavy growths occur to minimize the need for periodic treatment. Continuous application of copper sulfate, however, reduces the available food supply for fish and should be restricted to reservoirs used exclusively as sources of public water supply.

Periodic applications of copper sulfate may be accomplished by any one of the following methods: (1) by dragging bags of copper sulfate crystals behind a boat, (2) by dragging special, screened boxes, containing the copper sulfate, attached to the sides of a boat, (3) by the use of motor driven blowers discharging the copper sulfate in powder form or (4) by the use of conventional tree spraying equipment to distribute a solution of copper sulfate over the water's surface. A continuous dosage can be applied through the use of either commercially available chemical feeders or home-made solution tanks equipped with some means of controlling the discharge rate.

Because of its ease of application and small cost, copper sulfate provides a practical means for controlling microorganism growth in reservoirs. The important principle is that the application rates refer to average concentrations in the upper 10 feet of water. Care should be taken to distribute the copper sulfate uniformly over the area being treated.

Chlorine is also used to control the growth of microorganisms. Experience has shown that concentrations of free residual chlorine between 0.2 and 1.0 mg/l are effective in destroying most microorganisms. It is practically impossible, however, to maintain this chlorine residual throughout large open reservoirs because the chlorine reacts with organic matter and is dissipated by sunlight. Stabilization of chlorine with ammonia provides a simple procedure for maintaining adequate concentrations, especially if the treatment is continuous and is intended to prevent rather than destroy the growth of algae.

Algae thrive in shallow pools in swampy areas. Hence, such areas within the limits of the reservoir drainage area should be eliminated when possible. For the same reason, shallow portions of reservoirs should be avoided, or at least given special attention when treating with copper sulfate. Deep reservoirs should be fitted with intake structures permitting water to be drawn from various depths. Ordinarily, water near the surface contains the highest concentration of microorganisms. Water near the bottom of a reservoir is likely to be devoid of oxygen and contain large concentrations of decomposing organic matter, iron and manganese dissolved from the submerged soil and rock.

In most cases, water from an intermediate level should be used. Frequent tests should be made of the water at various depths near the intake so that the water may be taken from the level producing the most satisfactory water.

"Aeration" is a relatively simple treatment for taste and odor control but its use and effectiveness are rather limited. However, aeration usually reduces the load on other taste and odor control processes.

Activated Carbon

The use of activated carbon, a material specially treated to produce a surface condition of great adsorption capacity, is very effective in removing most tastes and odors. It is generally used in the form of a fine powder in dosages ranging from 10 to 50 lbs/million gallons. At times, as much as 300 lbs/million gallons are required for brief periods.
Application of carbon to the raw water will minimize the decomposition of sludge deposits in sedimentation basins. However, carbon seems to be more effective in removing taste and odor when it is on the surface of the filters where intimate contact with the filtering water is assured. Because of this, the practice has developed of adding small, uniform doses of carbon to the raw water, and adding varying and relatively larger doses to the settled water.

Many operators prefer to apply relatively large amounts for brief periods of time to individual filters immediately after each backwashing. This procedure has the advantage that an adequate, but not too great, amount of carbon is present on the filter bed throughout its operation period. Disadvantages are the difficulty of getting a uniform coating over the surface of the bed and the possibility of a decrease in the efficiency of taste and odor removal towards the end of the filter run.

Granular activated carbon is sometimes used as a filter, with the water passing through the beds at the rate of two to four gpm/sq ft. Since large amounts of activated carbon are quite effective in removing chlorine from water, the use of carbon filters is limited to applications before chlorination or when dechlorination as well as taste and odor removal is desired. The carbon granules become coated and the minute pores become clogged unless the water is clear. Therefore, carbon filters usually follow sand filters. Carbon filters must be washed at intervals but eventually their adsorptive power is exhausted and the carbon must be replaced or "reactivated".

Unfiltered surface supplies occasionally have objectionable tastes and odors owing to decomposition of aquatic vegetation and algae. Copper sulfate should be used to prevent or destroy algae growths, but this treatment may lead to temporary difficulty due to decomposition of the algae so destroyed. As a result of this situation, powdered activated carbon can be applied directly to water in the reservoir to adsorb taste and odor producing substances.

Chlorination is also an efficient method for corrective treatment if added in proper amounts beyond those required for disinfection. Sometimes such large concentrations of chlorine are required that subsequent dechlorination is necessary.

Ozone treatment is not a new method but has not received much attention until recently. Ozone has disinfecting properties but since it is more expensive than chlorine its use has been limited to taste and odor control. It has a decided advantage in that no after-tastes are produced and careful control of the maximum dosage is not of great importance. Ozone is an active, unstable form of oxygen which must be produced at the point of use by a machine called an ozonator in which an electric charge changes some of the oxygen in the air to ozone. This "ozonated" air is then compressed and bubbled through the water being treated in special "aeration" units.

Chlorine Dioxide

In the last decade, the use of chlorine dioxide in the water works field has been developed. Chlorine dioxide, ClO_2, is a heavy, reddish-yellow gas with a pungent disagreeable odor. A very active oxidizing agent, it is used extensively to treat water supplies along the Niagara River. With those water supplies, the treatment has been found effective in controlling tastes and odors due to chemical contamination, particularly from phenolic type compounds.

While used primarily for taste and odor control, it has been found that satisfactory bacterial reductions have been obtained. The method is at least as effective as chlorine in the normal pH ranges and more effective at the higher values.

Chlorine dioxide is produced at the water treatment plant at the time that it is used. It results from the reaction of sodium chlorite and a strong chlorine solution at a pH of less than 4. As chlorine dioxide is generated as needed, the reaction must be essentially completed before the final product is added to the water to be treated. Therefore, the solutions of sodium chlorite and chlorine are passed into a reaction chamber which provides a sufficiently long detention period and agitation.

When the chlorine solution is in the form of a hypochlorite, it is necessary to add an acid to the hypochlorite solution before it contacts the sodium chlorite. This is essential in order to depress the pH to 4 or less, as indicated above.

Chlorine dioxide is applied either as pre- or post-treatment. As in the case of chlorine, more chlorine dioxide is required when pretreating because of the demand that may exist in the untreated water. The effective dosages are determined in much the same manner as in chlorination, that is by laboratory study, because the demand of a water supply for chlorine dioxide is subject to wide changes.

Potassium permanganate in solution may be used to control tastes and odors. It has the ability to oxidize organic material in low concen-

trations. In general dosages of one to two ppm have been found effective when applied with the coagulant. As manganese is undesirable in the finished water, periodic testing to determine the proper dosage is important.

Distribution System Complaints

An effluent free of taste and odor does not always remain that way. Some taste and odor problems originate in the distribution system. Samples should be collected from taps of complaining consumers. Tests such as temperature, type of taste and odor, threshold odor number and pH, will establish whether water quality has deteriorated. Results of records kept over the years can point to deficiencies in the distribution system that need correction and help identify the sources of unusual taste and odor problems in the future.

TASTE & ODOR CONTROL*

General

Water must be free from taste and odor as well as safe. If the water supply has an unpleasant taste or odor, consumers will probably use any other available supply, whether or not it is safe. Taste and odor control involves treatment to prevent taste or odor formation or corrective treatment after formation.

a. *Causes.* The principal causes of unpleasant taste and odor in water are:
   (1) Pollution by industrial wastes, such as canneries, chemical manufacturing plants, and byproduct coke plants.
   (2) Excessive algae growths and slime deposits.
   (3) Decomposition of organic matter.
   (4) Dissolved gases, such as hydrogen sulfide, H_2S.
   (5) Iron and manganese.

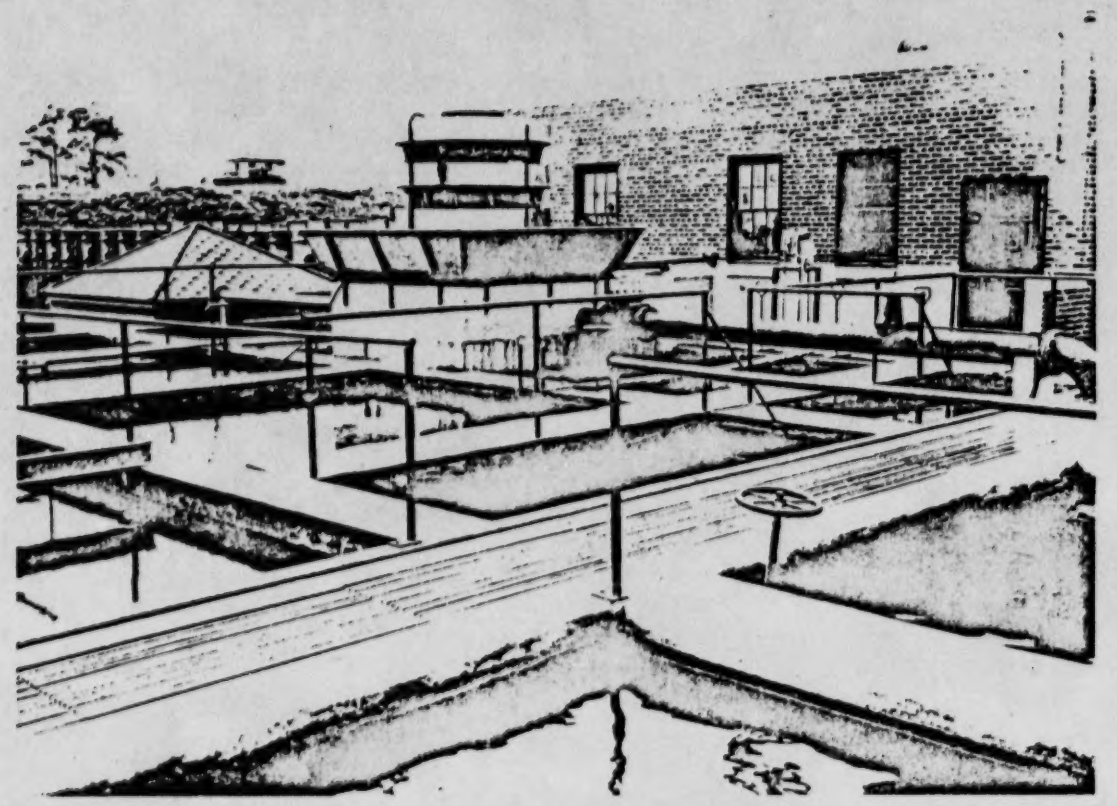
b. *Treatment.* Depending on the causes, taste and odor can be removed by aeration or by treatment with activated carbon, copper sulfate, or chlorine. Chlorine dioxide, made by reacting sodium chlorite with chlorine, has been found effective in combating tastes and odors caused by phenolic compounds. Taste and odor control chemicals may be added to the raw water, during rapid mix or flocculation, after sedimentation, or prior to filtration. Treatment methods are detailed in the following paragraphs.

Aeration

Aeration consists essentially of exposing as much water surface as possible to the air. During aeration, gases dissolved in the water supply are released to the atmosphere; soluble iron salts are oxidized and become insoluble so they can be removed by settling. Aeration raises the pH by eliminating dissolved carbon dioxide but increases corrosiveness by increasing the amount of dissolved oxygen. Types of aerators consist of overflowing trays or trays containing slats or coke over which the water is sprayed (figures 1 and 2). Other methods of aeration include spraying water up over a shallow receiving basin, and forcing air into a basin with diffusers or mechanical pump type aerators similar to those used in sewage treatment. Operation of most aerators is practically automatic; operators' duties consist essentially of making sure pipes, slots, and surfaces are not clogged and that air has free access to the water. If the water is not to be filtered after aeration, aerators must be screened with fine screen to keep out insects and other foreign matter.

*Source: Adapted from Maintenance and Operation of Water Plants and Systems, Department of the Air Force, Air Force Manual No. 85-13, June, 1968, pp. 156-160.

Figure 1. Aerator for Treating Water

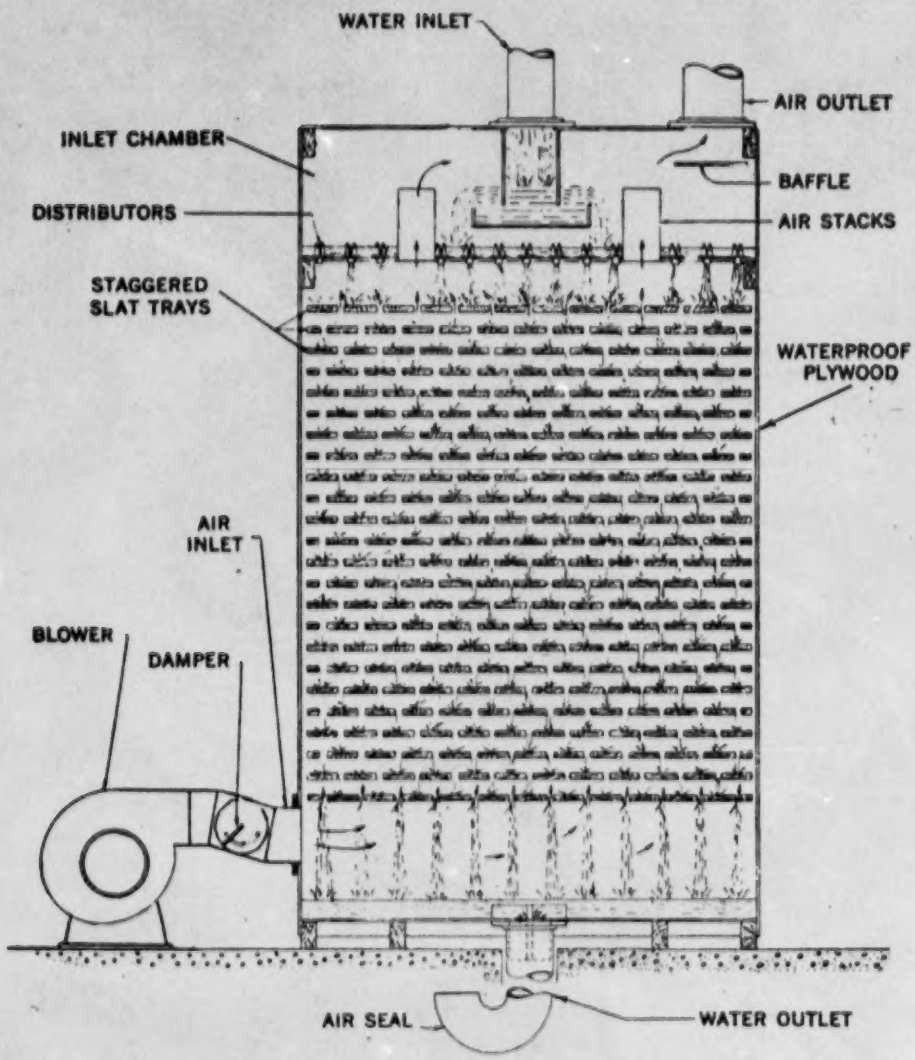


Activated-Carbon Treatment

a. *General.* Activated carbon is specially treated granular or powdered carbon which, because of its increased surface area, will adsorb larger quantities of dissolved gases, liquids, and finely divided solids than ordinary carbon. It is highly effective in taste and odor control, provided that the type of activated carbon used meets required standards, the dosage is correct, the carbon is mixed intimately with the water, and the carbon is in contact with the water for an adequate period.

b. *Minimum Standards.* Acceptable commercial preparations of activated carbon are available under a number of trade names such as *Aqua Nuchar, Cliffchar, Hydrodarco,* and *Norit.* Any type may be used if it meets the following minimum specifications:
(1) It does not contain any soluble mineral injurious to health.
(2) Weighs 10 to 11 lbs. per cu. ft.
(3) Moisture content is not over 8.0 percent.
(4) Contains at least 90% pure carbon.
(5) It is in powdered form which wets down and goes into suspension readily, does not settle too rapidly, and does not float on the surface when applied.

Figure 2. Forced Draft Aerator

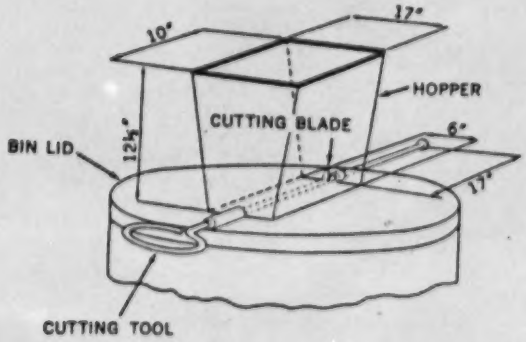


(6) At least 99 percent of the carbon in water suspension passes a 100 mesh sieve and at least 94 percent passes a 200 mesh sieve.
(7) It has enough adsorption capacity so that the amount, expressed in ppm, required to reduce a concentration of 0.1 ppm phenol in distilled water to 0.01 ppm shall not exceed 30. This is known as the phenol valve and is very important if removal of phenol is required. However, this test may be misleading if the activated carbon is being applied for other purposes as different carbons are highly selective. A carbon which gives excellent results for one purpose may not be satisfactory for another. Make field tests of samples of different carbons and select the one most satisfactory for the intended use.

c. *Dosage.* Because of the wide range in waters, no general rule can be given for activated carbon dosage. The dose required at each plant must be determined by periodic laboratory tests. The test is made by preparing a number of samples of raw water, adding standard amounts of treating chemicals and varying amounts of carbon to each sample, allowing plant contact time, filtering, and making odor tests. A carbon dose of 3 ppm removes most tastes and odors from water. However, if the tastes and odors are caused by pollution from industrial wastes, the dose may have to be increased to 8 to 10 ppm, or even 20 ppm at times. When odors develop suddenly, feed an excess dose until they are under control.

d. *Methods of Application.* Normally activated carbon is fed into the water by dry feeders somewhat similar to those used for coagulants. Because activated carbon is so finely powdered, it must be handled more carefully than coagulants to guard against spreading carbon dust and causing fires or explosions. Modification of a dry feeder to prevent spread of dust is shown in figure 3.

Figure 3. Device to Prevent Dust Spreading When Activated Carbon is Applied



In addition, motors, lighting fixtures, and switches must be explosion-proof. If dry carbon were dry-fed onto the water it would float on the surface for a long time. Therefore, to insure better mixing, the carbon is first wetted thoroughly, usually by agitating it with the feed water in a small box or tank. The agitating agent may be a paddle wheel, a strong spray, or a swirling action obtained by introducing the feed water at a tangent to the side of the tank. Most carbon dry feeders have a mixing chamber or hopper in which the carbon is wetted by the swirling action of the water.

e. *Points of Application.* Activated carbon may be applied to the water at one or more points, depending on results desired. Usually carbon is added at one of the following points:
(1) *In Raw Water.* As early as possible after entering the plant, but this point of application is not recommended for extremely turbid water.

(2) *In Mixing Basin.* When added before sedimentation, activated carbon not only removes foreign matter from the water, but the carbon which settles in the sedimentation basin continues to adsorb products of sludge decomposition, thus preventing formation of secondary tastes and odors. It also permits the use of high dosages without adversely affecting the length of filter runs. Black alum is premixed activated carbon and coagulant that can be used in special situations both as a coagulant and for taste and odor control.

(3) *In Treatment Plants.* Applying carbon just before filtration is recommended because then it is not removed during coagulation and flocculation and its effect continues during the filtration process. The carbon that accumulates in the filter helps remove tastes and odors. When a filter is returned to service after backwashing, it is good practice to add a small batch of carbon to the filter influent.

(4) *Split Feed.* When part of the dosage is applied in the mixing basin and the balance just ahead of the filters, it is referred to as a split feed. Proportions of the dosage at these two points depend on the water being treated. This method combines the advantages of both feed methods.

(5) *In Filters.* Granular activated carbon can be used as the filter medium in gravity or pressure filters. Operation is identical to that of sand filters, but backwash rates are lower to prevent loss of carbon.

(6) *With Chlorine.* Chlorine frequently alters the intensity of odors. If chlorine makes the odor harder to remove, carbon feed should precede chlorination; if chlorine makes the odor easier to remove, carbon application should follow chlorination.

LABORATORY EQUIPMENT AND SUPPLY REQUIREMENTS FOR A SMALL WATER TREATMENT PLANT PROVIDING COMPLETE TREATMENT

Published by

WEST VIRGINIA STATE HEALTH DEPARTMENT
Environmental Health Services
Drinking Water Program
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Charleston, West Virginia 25305
Telephone: (304) 348-2981
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The following laboratory equipment and supplies are required of small water treatment plants for determining the physical-chemical parameters of chlorine residual (free and total), turbidity, pH, alkalinity, free carbon dioxide, hardness, fluoride ion, and performing the "jar test" for proper coagulant dosage.

Vendors not noted below, but capable of supplying equipment equal to that which is listed are acceptable. However, the Environmental Health Services Laboratory (telephone 348-0197) should be consulted before purchasing agreements are made with these vendors to confirm that equivalent equipment is being offered.

Item Number	Quantity	Items
1	1	Copy of latest edition of "Standard Methods for the Examination of Water and Waste Water", American Public Health Association, Inc., 1015 Eighteenth Street, N.W., Washington, D. C. 20036
2	1	Balance, Harvard Trip Scale, single beam, Ohaus #1450
3	1 set	Technical weights, metric, class C, 1 gm to 1000 gms
4	1	pH meter - accuracy ± 0.05 unit, scale readability ± 0.1 pH unit. Instruments meeting specifications of the Corning model 7, the Orion model 601, Beckman Zeromatic, Fisher Accumet, or equivalent are satisfactory. Laboratories purchasing a new pH meter are strongly advised to purchase one capable of functioning with specific ion electrodes.
5	3	Burettes, Automatic, with stopcock, for dispensing sulfuric acid and hardness reagent, also N/44 sodium hydroxide, 50 ml. capacity, 1/10 ml. subdivisions, complete with rubber bulb and reservoir.

LABORATORY EQUIPMENT AND SUPPLY REQUIREMENTS FOR A SMALL WATER TREATMENT PLANT PROVIDING COMPLETE TREATMENT

Item Number	Quantity	Items
6	1	Burette Support, with large white porcelain base and a 3 way castaloy burette holder for assembling and steadying automatic burettes with reagent reservoirs.
7	1	Therometer, - 20° to 110° C.
8	4	Casseroles, porcelain (Coors #180), 210 ml.
9	6	Stirring rods, glass, 3mm diameter
10	6	Pipettes, water analysis, 10 ml. capacity
11	2	Cylinders, graduate, 100 ml. capacity, 1.0 ml. subdivisions
12	3	Flasks, Erlenmeyer, wide mouth, 250 ml.
13	6	Beakers, Griffin, "Pyrex", 1000 ml. (for jar test)
14	6	Bottles, dropping T. K., 60 ml.
15	1	DPD Chlorine residual colorimetric test kit. LaMotte, Hach, Taylor or equivalent are satisfactory kits. Kits must include free and total residual capabilities.
16	1	Turbidimeter (Nephelometric only) - Hach Turbidimeter 2100 A, Sargent-Welch, Turner Designs, Monitek, or equivalent. TURBIDITY ANALYSIS IS REQUIRED ONLY FOR THOSE SUPPLIES TREATING SURFACE SOURCE WATERS. Calibration of sealed liquid turbidity standards sealed liquid turbidity standards purchased from the instrument manufacturer must be checked frequently for settled and floating particles in order to monitor their eventual deterioration. These standards should be replaced when any major change from the previous calibration occurs or sediment appears. Solid turbidity standards composed of plastic, glass, or other materials are not reliable and should not be used.

LABORATORY EQUIPMENT AND SUPPLY REQUIREMENTS FOR A SMALL WATER TREATMENT PLANT PROVIDING COMPLETE TREATMENT

Item Number	Quantity	Items
17	1	Distilling apparatus, automatic, bantam still, capacity 1.8 liters per hr., Barnstead or equivalent with 2 gallons of distilled water storage. (Preiser Scientific - Catalog #17-8360 or equal)
18	2	Propipette Bulbs
19	1	Filter photometer, AC, Hach or equivalent (Hach No. 110400, 115 V, 60 Hz) with capabilities for iron, manganese, fluoride (SPADNS) method, Nitrate (cadmium reduction), with necessary reagents.
20	1	Specific ion meter - expanded scale millivolt capability, readable and accurate to 0.1 millivolt. Instruments meeting the specifications of the Orion model 407 A, the Orion model 801 A, the Corning model 110, or equivalent are satisfactory, complete with specific ion electrodes. FLUORIDE ANALYSIS REQUIRED ONLY FOR THOSE SUPPLIES FLUORIDATING.
21	1	Automatic Batch Fluoride still, Hach or equivalent, Hach Catalog #592. NOTE: If the SPADNS colorimetric method for fluoride is used, all samples must be distilled before this determination is made. If the specific ion electrode method is used (as mentioned in item #20 above), this piece of equipment can be omitted.
22	1	Stirring apparatus for "jar test", 6 unit, with variable speed control and light reflector.
23		Chemical Supplies:
	32 oz.	Sulfuric Acid, N/50 solution
	32 oz.	Sodium Hydroxide, N/44 solution
	16 oz.	Methyl Orange indicator solution
	16 oz.	Phenolphthalein indicator solution
	8 oz.	Sodium Arsenite reagent
	16 oz.	Buffer Hardness reagent
	2 vials	Hardness indicator powder (EDTA)
	32 oz.	Hardness Reagent (titrating)
	32 oz.	SPADNS Reagent
	16 oz.	Fluoride solution, standard 1.0 ppm
	1 gal.	TISAB (for use with specific ion electrode

LABORATORY EQUIPMENT AND SUPPLY REQUIREMENTS FOR A SMALL WATER TREATMENT PLANT PROVIDING COMPLETE TREATMENT

Item Number	Quantity	Items
23 cont.		method for fluoride analysis).
	1 pint	pH Buffer 7.0
	1 pint	pH Buffer 4.0

LABORATORY FACILITIES - General Notes

1. Adequate laboratory space should be made available. As a guideline, there should be approximately 150 to 200 square feet per person, regardless of test, and approximately 15 linear feet of usable bench space including a sink with hot and cold water taps.

2. Raw and post-settling water taps should be provided in the laboratory area for quality control monitoring.

3. Sufficient electrical outlets must be provided for operating the laboratory equipment.

4. GLASSWARE - all glassware purchased for laboratory use should be composed of PYREX or KIMAX type glass. This type of glass is more resistant to damage by heat, chemicals, and abuse than is regular soft glass. All volumetric glassware should be marked CLASS A, denoting that it meets federal specifications for volumetric glassware, and need not be calibrated before use.